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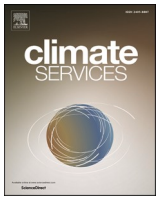

The challenges of implementing adaptation actions in Scotland's public sector

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ABSTRACT

This research examines the progress made by the public sector in Scotland from risk assessment to adaptation planning and implementation. We highlight some key challenges faced by the public sector in Scotland that are leading to a lack of progress in the adaptation space as noted in a recent UK Climate Change Committee report, "Is Scotland climate ready? – 2022 Report to Scottish Parliament". This report highlighted the lack of analysis of the adaptation section of public bodies duties reports in Scotland and our research is the first in-depth analysis of this section at time of writing supplemented by interviews with a range of public sector bodies. The key research questions we consider are: "What tools, frameworks, data and knowledge are currently being used to conduct risk assessments for adaptation?"; "What kind of tools, frameworks, knowledge and data may be helpful for decision makers in this space?" and "What challenges and barriers exist for public sector bodies throughout their adaptation journeys?" By first setting out the key challenges currently facing the public sector in Scotland, we then present a range of potential solutions that could be implemented in Scotland to increase adaptation action. This study can help bridge the gap between climate science and decision makers by making it clearer what the requirements are for future tools, models and data to help accelerate adaptation action and how it is reported on and evaluated.

Practical implications

The ability to manage climate risks and adapt to climate change is becoming increasing important as the intensity and frequency of extreme weather events increase globally (Seneviratne et al., 2021). In Scotland, progress made towards adaptation goals is assessed by the Climate Change Committee whose recent report "Is Scotland climate ready? – 2022 Report to Scottish Parliament" (Climate Change Committee, 2022) highlighted that Scotland's progress in delivering its adaptation aims had stalled across most sectors and it emphasised the need to raise the level of adaptation response. This research examines the progress made by the public sector in Scotland from risk assessment to adaptation planning and implementation. We highlight some key challenges faced by the Scottish public sector that are leading to a lack of progress in this space and we discuss some potential solutions.

Our research finds that the public sector in Scotland overall is in the development and planning phase of adaptation. 33 % of bodies are completing a risk assessment that assesses current and future risks however questions have arisen about how fit for purpose these risk assessments are and if undertaking a risk assessment leads to the implementation of adaptation actions. A key theme emerging from this research was the distinction between mitigation and adaptation with numerous interviewees stating that the implementation of adaptation actions is lagging behind mitigation. We, therefore, review the key commonly cited differences between adaptation and mitigation at a local level. Differences arise between the two in terms of the complexity associated with each, the risk and level of uncertainty involved, the collaboration and number of actions required and in terms of measurements and targets in the current policy space.

Adaptation is understood to be more complex than mitigation

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within the Scottish public sector. There are a limited number of adaptation "champions" in the public sector who are required to upskill and to raise awareness of adaptation in their teams. This lack of understanding of adaptation at an organisational level means that not all adaptation actions are being monitored as such. This is also leading to capacity issues as there are a small number of adaptation "champions" who are responsible for: gaining buy-in from colleagues, upskilling and implementation. Including adaptation in organisation wide carbon literacy training may help to ensure that adaptation awareness matches that of mitigation. Stronger legislation could also push adaptation up the agenda, acting as an external pressure leading to greater buy-in.

A wider variety of approaches to risk and uncertainty are required by the public sector. The most prominent forms of risk assessment currently used are around cost-benefit analysis. There is a need for more approaches to decision making under uncertainty to be taken up by the public sector. By exploring differing storylines or narratives or through serious games where decisions are made under uncertainty, organisations can experience decision making for an unknown future, under different conditions from the past while gaining experience of making legitimate decisions under high uncertainty levels (Lawrence and Haasnoot, 2017; Rumore et al., 2016; Wu and Lee, 2015). This form of risk management, through scenarios, or climate narratives, ensures that risk assessments do not rely on occurrences of events or on the likelihoods of past events alone (Wassénius and Crona, 2022) as is currently the process in the Scottish public sector for a number of bodies based on interviews and report analysis. While bodies are receiving guidance on adaptation, the requirements for adaptation including what scenarios bodies are required to use remains unclear. The role of a boundary organisation for the public sector would be to co-produce scenarios and storylines for regions in the public sector while allowing for collaboration between regions and bodies. This organisation could also facilitate the creation of adaptation pathways bringing together public sector bodies and communities where collaboration is paramount and help to fill the current skills gap and capacity challenges.

Collaboration is a commonly cited difference between adaptation and mitigation as well as the number of actors involved as mitigation is often considered to consist of a few key actors (Klein et al., 2005). Public sector bodies in Scotland cover a wide range of sectors and are responsible for or play a part in many of these sectors required for adaptation. This makes public sector bodies key interfaces to tackle the challenge of the need of multiple actors (Climate Ready Clyde, 2020; Heidrich et al., 2013). While collaboration and co-production can be challenging (Porter and Dessai, 2017), there is evidence that collaboration is currently happening in the public sector and this emerged as a key theme of our research. However, siloes, both departmental and sectoral, are still acting as a barrier to adaptation.

Mitigation progress and actions can be measured under one metric, CO2-equivalents, whereas measuring adaptation progress is more complex as benefits can take multiple forms including monetary losses avoided, human lives saved or cultural values loss avoided (Klein et al., 2007). By reviewing the Scottish Climate Change Adaptation Plan, we highlight the complex landscape of adaptation outcomes for the public sector in comparison to mitigation while also highlighting the potential dangers of creating a single metric for adaptation. An alternative approach (Dilling et al., 2019) could be to focus on building long-term adaptive flexibility and capacity.

A key similarity between mitigation and adaptation in the Scottish public sector, and in other regions globally, is that there is a current gap between planning and implementation (Climate Change Committee, 2021b). Therefore, a greater understanding of the synergies, co-benefits and trade-offs between mitigation and adaptation actions as well as the links to other policy areas including reducing poverty and healthcare, we believe would bolster effective adaptation action.

Introduction

The ability to manage climate risks and adapt to climate change is becoming increasing important as the intensity and frequency of extreme weather events increase (Seneviratne et al., 2021). In Scotland, winters are becoming wetter and sea level rise around the coast has increased up to 3 cm per decade over the last 30 years (Climate Change Committee, 2022). The average temperature in Scotland has increased by 0.5 % over the same time period. While adaptation is a key component of international climate agreements (Lee et al., 2022; United Nations / Framework Convention on Climate Change, 2015) "adaptation gaps" have been identified worldwide in relation to planning, finance and implementation (Goldstein et al., 2019; United Nations Environment Programme, 2021). Scotland responds both to a UK and Scottish climate change policy framework mainly through the UK Climate Change Act 2008 and the Climate Change (Scotland) Act 2009. A Climate Change Risk Assessment (CCRA) is required by the UK act every five years which forms the basis of adaptation policy in the UK and in Scotland (Adaptation Scotland, 2022). Scotland's adaptation plan is set out in its second Scottish Climate Change Adaptation Programme (SCCAP2) (Scottish Government, 2019) which addresses the Scottish specific impacts identified in the UK CCRA. Progress towards the goals set out in SCCAP2 is independently assessed by the Climate Change Committee whose recent report "Is Scotland climate ready? – 2022 Report to Scottish Parliament"(Climate Change Committee, 2022) highlighted that Scotland's progress in delivering its adaptation aims had stalled across most sectors and it emphasised the need to raise the level of adaptation response. Public bodies in Scotland have a duty to annually report their climate mitigation actions as well as their contribution to delivering SCCAP2 (Sustainable Scotland Network (SSN), n.d). They do so, by reporting to the Scottish Government through Public Bodies Climate Change Duties (PBCCD) reporting. However, the adaptation section of the reports are currently not being analysed routinely by the Scottish Government and therefore have provided minimal evidence of approaches public sector bodies are taking to assess risk, plan and implement adaptation as well as the challenges they are facing (Climate Change Committee, 2022).

The concept of applying a risk management framework in the context of climate change is strongly developed, particularly since IPCC AR5 where risk was presented as a product of hazard, exposure and vulnerability (IPCC, 2014; Sainz de Murieta et al., 2021). An IPCC cross-working group report as part of AR6 stated the core definition of risk as the "potential for adverse consequences" (Reisinger et al., 2020). While many public and private sector bodies have processes in place to conduct risk assessments, those related to climate change and climate risk pose challenges (Goldstein et al., 2019) due to the level of uncertainty involved. Traditional risk assessments tend to be appropriate for situations where knowledge about possibilities and probabilities are unproblematic (Stirling, 2010). This is infrequently the case when assessing climate risk where complex systems are involved that may have nonstandard variation across time (Wassénius and Crona, 2022). Climate risk assessments therefore require input from a range of disciplines and perspectives using both quantitative and qualitative information, providing information on likely scenarios and on high impact, low probability events.

Our key research questions are: "What tools, frameworks, data and knowledge are currently being used to conduct risk assessments for adaptation?"; "What kind of tools, frameworks, knowledge and data may be helpful for decision makers in this space?" and "What challenges and barriers exist for public sector bodies throughout their adaptation journeys?" While literature exists around creating data, tools and science that are useful to decision makers in this space (eg Deubelli and Mechler, 2021; Lee et al., 2022; Sainz de Murieta et al., 2021; Tisch and Galbreath, 2018; Wilson et al., 2020) fewer studies aim to understand

Table 1
Number of public bodies per sector in reporting years 2019/20 and 2020/21 (including Integration Joint Boards which act as partnerships between the National Health Service and council in local regions around Scotland with a focus on the planning and delivery of local social care).

Sector	Number of bodies that responded to Q1: "*What are the body's top 5 priorities for the year ahead in relation to climate change adaptation?*"		Number of bodies that responded to Q2: *"Has the body assessed current and future climate-related risks?"*		Number of bodies in sector
	2019/20	2020/21	2019/20	2020/21	
Local Authorities	31	30	31	32	32
National Health Service	18	17	18	17	19
Educational Institutions	39	40	42	42	44
Transport Partnerships	7	7	7	7	7
Others*	42	46	41	48	48
Integration Joint Board	14	15	15	17	30
Total	151	155	154	163	180

* National and regional public bodies.

what kind of tools decision makers are currently using and where the key challenges lie when accessing, interpreting and using this information, even though the "translation gap" between climate researchers and decision makers has been documented (Bremer et al., 2019; Deubelli and Mechler, 2021; Milhorance et al., 2022). By analysing the regulatory reporting for adaptation, we have set out the challenges currently facing the public sector in Scotland and solutions that may progress the implementation of adaptation actions in the Scottish public sector. We discuss the barriers in relation to mitigation which is felt to have progressed further and faster in comparison to adaptation in order to understand how adaptation action may be accelerated. After setting out the method in section 2, we outline the key results from the report analysis and the interviews conducted before providing an in-depth critical analysis and discussion in section 4.

Method

An inductive approach was taken in this research. Two adaptation questions in the regulatory public bodies climate change reports were analysed and interviews conducted with a range of individuals in the public sector who have key roles in the completion of the duties reports.

Public bodies climate change reports analysis

We analysed the Sustainable Scotland Network (SSN) Public Bodies Climate Change Reporting 2019/20 and 2020/21 reports (Sustainable Scotland Network (SSN), 2022). The reporting timeframe was selected to align with the publication of the Second Scottish Climate Change Adaptation Programme (SCCAP2) 2019–2024 which was published in September 2019.

Public sector organisations in Scotland have a statutory duty to both reduce greenhouse gas emissions and to prepare for the impacts of climate change while reporting on progress made annually (Sustainable Scotland Network (SSN), 2022). In terms of mitigation, 75 % of public bodies have at least one emission target and over 20 organisations have set a net zero target with others setting sectoral targets. This research however is the first in-depth analysis that has been completed at time of writing on the adaptation section of the reports despite this section being part of the report since the first reporting year, 2015/16. Two key questions from the adaptation section have been analysed in this research, for the purpose of this research these will henceforth be labelled as Q1 and Q2, Q1: "What are the body's top 5 priorities for the year ahead in relation to climate change adaptation?" and Q2:"Has the body assessed current and future climate-related risks?" Two out of eight

Table 2
Adaptation priorities per sector (% of total number of references per theme split by sector) from Q1. Darker shaded segments relate to the higher number of references that public sector bodies made to a particular priority. Themes with the highest number of references include: developing a plan for adaptation, examining risks and impacts, using or developing relevant data sets, tools and frameworks for risk assessment or adaptation planning and working in partnership.

Theme	Transport partnerships	Local Government	National Health Service	Integration Joint Boards	Others	Educational Institutions	Total
Awareness & Communication	3	2	3	11	6	5	4
Behavioural Change	3	0	0	0	2	2	1
Buildings & Infrastructure	3	3	1	6	6	7	5
Climate Justice	0	0	0	0	0	0	0
Community Planning Partner & Place Based Adaptation	0	3	0	6	0	0	1
Demonstrate work & best practice	0	0	0	0	2	0	0
Finance & Costs	0	5	2	0	3	2	3
Employee Engagement	0	0	0	0	3	3	2
Energy Use & Emission Reduction	0	6	6	6	8	11	8
Ensure service to customers	3	1	1	0	2	1	1
Extreme weather & hazards	9	12	2	0	5	7	7
Flexible & Virtual working	3	0	1	0	4	1	2
Food & Agriculture	0	0	0	0	0	0	0
Human & Public Health	6	1	0	0	0	0	1
Learning & Training	6	3	3	0	6	6	4
Nature Based	3	8	2	0	4	3	5
Implement & Deliver Plan	0	10	4	11	4	4	6
Develop Plan	11	17	14	11	11	12	13
Recruitment	0	1	4	0	1	1	1
Reduce waste & Recyling	0	0	3	0	3	2	2
Risks & Impacts	14	8	18	11	9	9	10
Supply chain & Procurement	0	0	0	0	1	1	1
Sustainable Development	0	1	0	0	2	4	2
Targets Metrics KPIs & Standards	3	0	5	6	1	3	2
Travel & Transport	14	1	7	6	6	4	5
Use of Data Tools Models & Frameworks	6	5	15	17	4	6	6
Work in Partnerships & Collaborations	14	12	6	11	7	5	8
Total	100	100	100	100	100	100	100

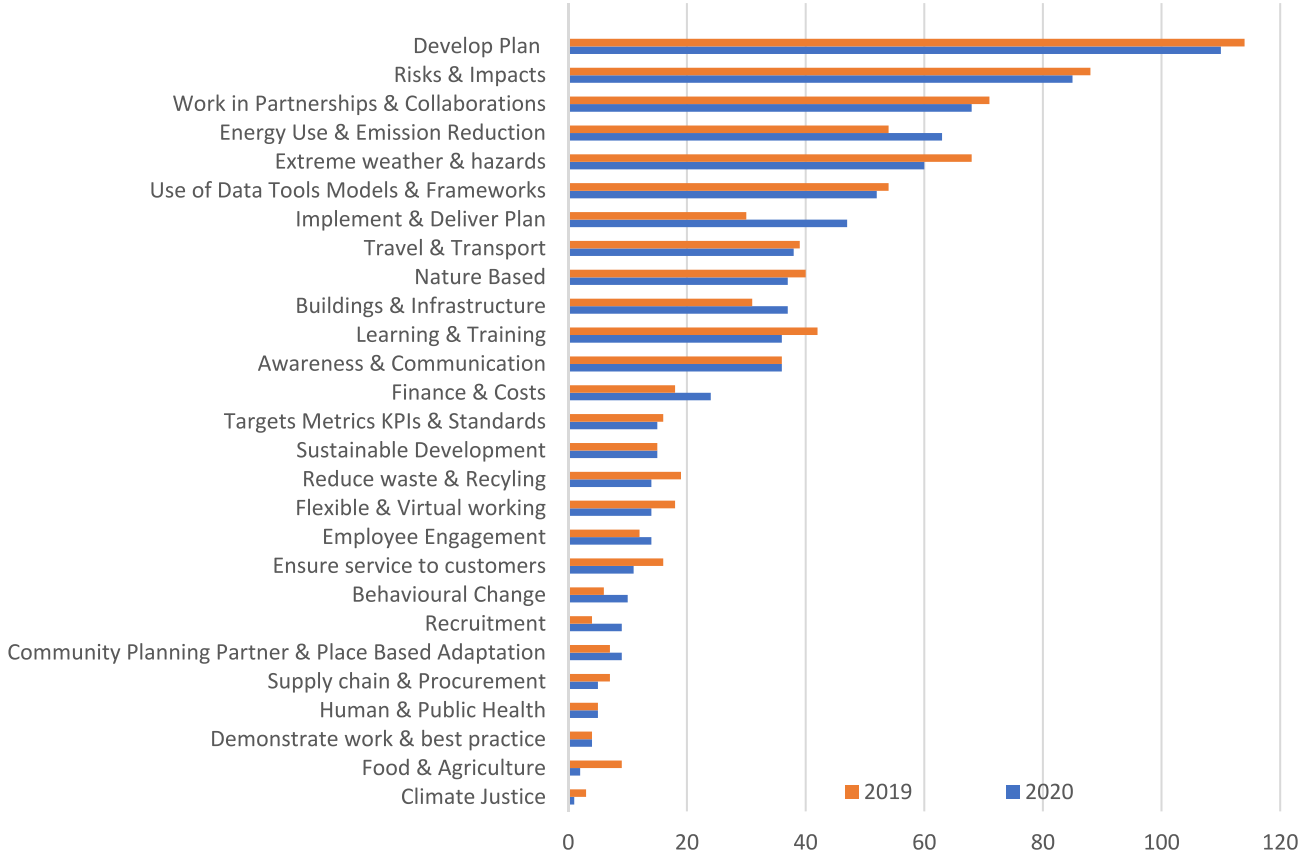

Fig. 1. Themes emerging from Q1: comparing 2019 and 2020 across all sectors which shows that bodies priorities are relatively stable across the two reporting years. This plot shows the number of references bodies across all sectors made to certain themes in their reports [Requires colour].

questions were selected from the reports as they allowed for an analysis of key themes and the responses to each question were distinct from one another. These questions were also selected as they were completed by more bodies in comparison to other questions. In the 2020/21 reporting year, 155 bodies answered the former question and 163 the latter out of 180 (Table 1). The responses to each question were thematically analysed using Nvivo2.

For Q1 each priority listed was coded at least once depending on how many themes it covered. For the reporting year 2019/20 this resulted in the creation of 76 codes initially each with between 1 and 51 references each. These codes were then regrouped into the 27 over-arching "themes"that are presented in the results section. This process was duplicated when analysing year 2020/21. Since many of the answers remained constant from year to year this process also helped to ensure validity of codes and themes created for the 2019/20 reporting year. For Q2 a similar approach was taken in order to produce the 11 themes specifically about risk management, in this case, in addition to the five categories created for the bodies' responses to Q2, "Has the body assessed current and future climate-related risks?". Q2 was independently analysed by the SSN secretariat for the Summary Analysis Report 2022 (Sustainable Scotland Network (SSN, 2022). This provided a comparative reference and ensured validity. An inductive approach was used in the thematic analysis of both Q1 and Q2 in an attempt to reduce the effect of researchers' bias.

Interview analysis

Ten targeted interviews were conducted with representatives of public sector bodies, at differing levels of adaptation planning and risk assessment and from different geographies around Scotland. The individuals selected from public sector bodies were those who complete or have significant input into the completion of the public bodies duty reports. The purpose of the interviews was to provide further depth to the responses presented in the reports, exploring the research questions further.

Semi-structured interview questions included: "Have you suffered from any extreme weather events in the past and are there any particularly on your radar?"; "What information, knowledge or data do you use in decision making/risk management related to extreme events?"; "Do you face any challenges around risk assessments or accessing data, information or knowledge?". In addition, questions were asked in relation to the bodies' specific report responses in the adaptation section of the public bodies duties reports. Therefore, semi structured interviews allowed the freedom to discuss different challenges or barriers with each interviewee while still addressing the key research questions.

Interviews were conducted online and were recorded. The transcriptions were then imported into Nvivo2 for analysis. Similar to the analysis of the report questions, an inductive approach was taken in the interview analysis where each interview was coded in a grounded theory "lite" approach (Braun and Clarke, 2006; Glaser and Strauss, 2010). Saturation was reached by interview 9 where few new codes were added either for interview 9 or 10. A similar approach has been taken by others in similar fields (eg Boiral et al., 2019; Ivory and MacKay, 2020; Tisch and Galbreath, 2018).

Results

Top adaptation priorities for public sector bodies

Table 2 provides a breakdown of the key themes per sector in relation to adaptation priorities from responses to Q1:"What are the body's top 5 priorities for the year ahead in relation to climate change adaptation?"

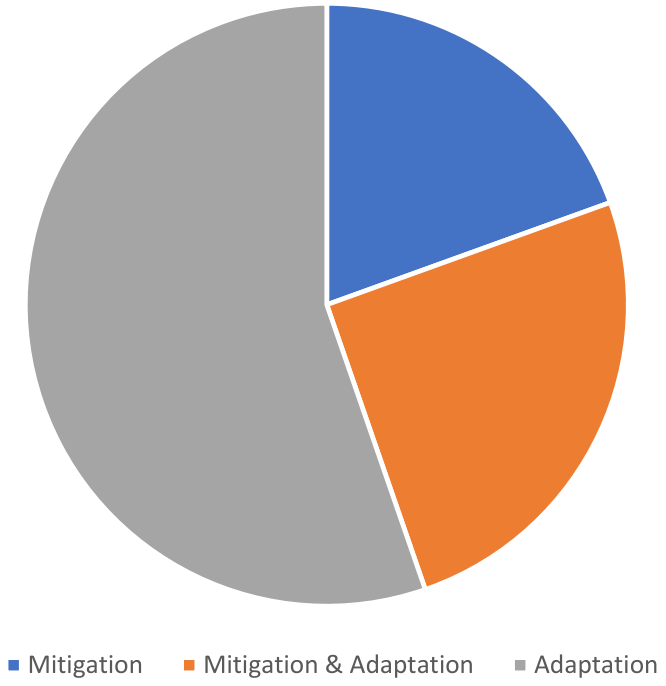

Fig. 2. Total references (across all themes) split into mitigation, adaptation or mitigation and adaptation 2020 [Requires colour].

Table 2 highlights the most common themes across all sectors such as "Develop Plan" and "Risk & Impacts" as well as indicating sector specific recurring themes such as "Climate Justice" that only emerges from responses from Local Government for example. Fig. 1 shows the themes emerging from this question across all sectors from two consecutive reporting years, 2019/20 and 2020/21. The two years were compared in order to understand how the adaptation priorities may change year on year since the publication of SCCAP2. Between the reporting years of 2019/20 and 2020/21 the themes discussed did not change significantly. "Develop Plan" has been the most referenced theme of these two reporting years suggesting that adaptation within the public sector in Scotland remains largely in its planning phase, a finding that aligns with the latest Climate Change Committee progress report (Climate Change Committee, 2022). When comparing the two reporting years, there are less references to "Develop Plan" in 2020 compared to 2019 and more references to "Implement & Deliver Plan" in 2020 suggesting some limited progress made between years. Table A1 in the app. endix gives examples of different priorities that fall under each theme. From the interviews, key adaptation priorities include creating databases of past events in order to learn from instances of past hazards as well as infrastructure and building based projects and nature-based solutions approximately aligning with the most referenced themes identified through the report analysis and with reference to Table 2.

Overall, this analysis identified common cross-cutting themes related to current adaptation discourse within the Scottish public sector at the time of reporting. These include linkages between adaptation and mitigation, risk assessments and the tools and frameworks currently used to complete them (eg Arribas et al., 2022; Klein et al., 2005; Lee et al., 2022; Sharifi, 2020; Wassénius and Crona, 2022).

Mitigation & adaptation

A common challenge for all public sector bodies is the separation between mitigation and adaptation in both the policy and scientific arena. The reports and interviews indicate that despite prioritising risk assessments, there remains confusion between the two areas. In particular limited progress on adaptation has been blamed on its broad and vague nature particularly when compared to mitigation. Therefore, the top adaptation priorities for the year ahead listed by the bodies (in Table 2) were reviewed in order to ascertain whether they were in fact adaptation focused as opposed to mitigation and to identify priorities that could be considered to be both a mitigation and adaptation action. During the interviews this was further explored via questions relating to the inter-relationship between mitigation and adaptation and the existence of any synergies or trade-offs. Priorities were categorized according to the IPCC definitions of adaptation and mitigation *(*IPCC, 2001a, pp5*)*.

Fig. 2 illustrates that while 55 % references across all themes were made to adaptation actions while discussing priorities for the year ahead, 20 % of references were made to purely mitigation actions. Exploring each theme individually, Fig. 3 shows that that the split between adaptation and mitigation differs even within each theme. For example, under the theme "Energy Use & Emission Reduction" the majority of references were made to mitigation such as investing in renewables to reduce greenhouse emissions while some references were made to both mitigation and adaptation for example insulation to improve energy efficiency and building resilience. Since there is a separate section dedicated to mitigation in the public bodies duties reports, bodies should not be reporting on mitigation actions within the adaptation section of the report unless there are significant areas of overlap. Most themes include priorities that cover both adaptation and mitigation demonstrating the interconnectedness between the two and the potential for synergies. For example, themes around raising awareness, training and behavioural change have the potential to include and address both concepts.

The idea that adaptation is secondary to mitigation in terms of progress made was raised by several interviewees, with one stating that "we are getting progress now and people asking questions, but the focus still tends to be on carbon reduction"; and another noting that "most public sector organisations are aware of adaptation but I think it's been the poor relation to mitigation". The first cited reason for this is the idea that mitigation is "a bit easier for people to understand" whereas adaptation is believed to be more complex. An example was provided in which a public sector employee who was hired to work on adaptation, biodiversity and mitigation found that they struggled to "get their head around adaptation or the adaptation agenda" they felt "it was difficult to learn about" when the employee "came from a standing start across their remit…but felt they could take on" the biodiversity and mitigation work more so than adaptation. A second key reason is around measurement and how interviewees believe that "climate change mitigation is easier to measure" than adaptation. Furthermore, the targets and drivers to reduce carbon emissions were cited as a reason for adaptation lagging behind mitigation in terms of planning and implementing actions. While co-benefits and synergies between mitigation and adaptation were discussed, the fact that measurable targets are in place for emission reductions as well as the funding available for mitigation was cited as a key reason for the lag in adaptation action with individuals stating they "need to work a bit on bringing an equal or even more focus on adaptation". Lastly, targets for mitigation can also be longer term, whereas creating a long-term adaptation strategy is felt to be more difficult due to short-term political influences and annual budgeting, "we'd have a [long-term] target in terms of carbon neutral and net-zero by 2045…but certainly no written down plan [for adaptation]".

Another key difference between mitigation and adaptation cited by the majority of interviewees was in relation to the complex terminology used in relation to adaptation. The need for a "translation" of acronyms was raised and there was also discussion about the difference between the terms "adaptation", "resilience" and "climate ready" with the idea that "adaptation is probably not understood across the organisation". The translation of terms and emergence of new terms is a common challenge for cross sectoral work such as in adaptation and risk reduction (Vogel et al., 2007). This can lead to challenges around reporting with interviewees mentioning that their organisation is likely to be

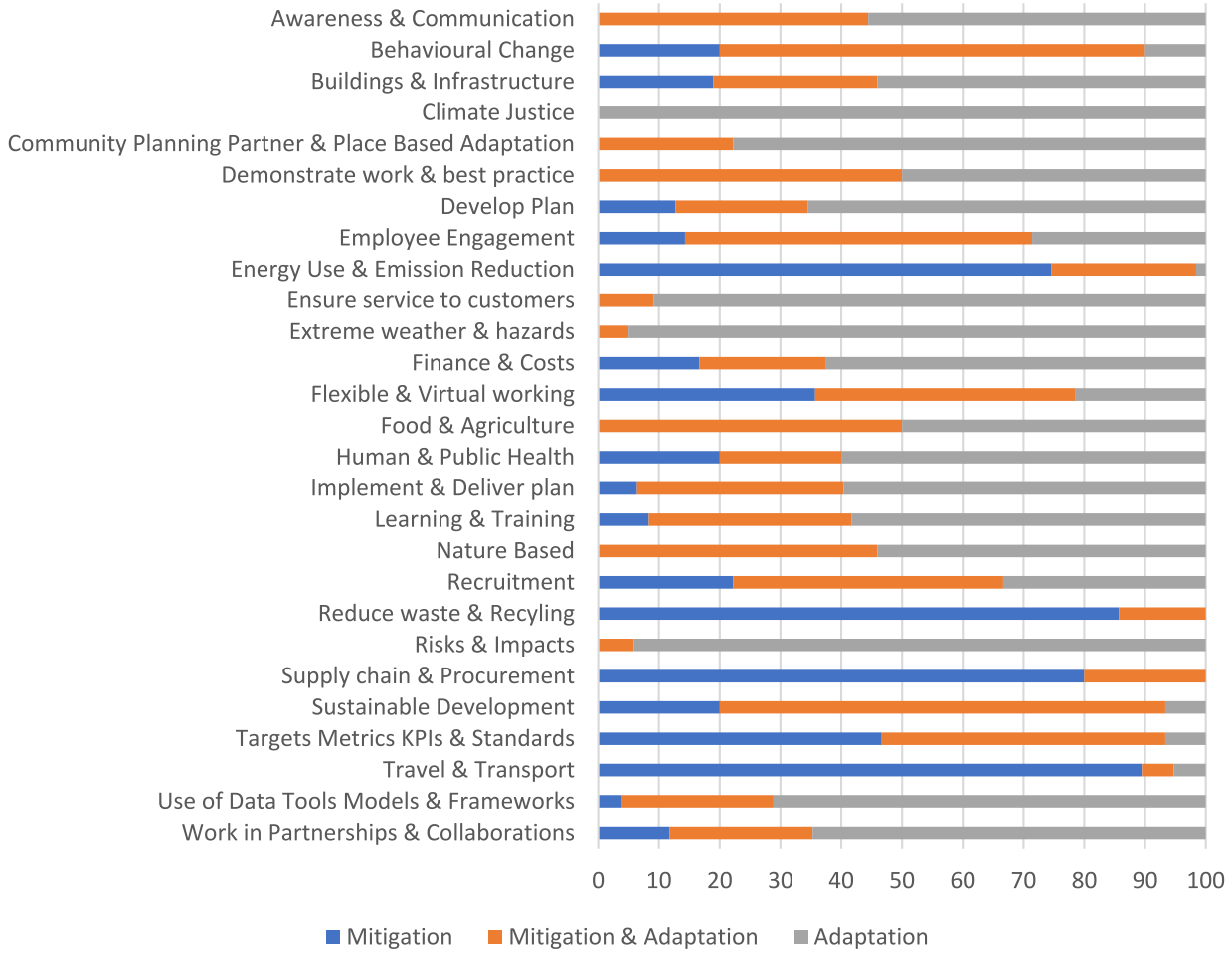

Fig. 3. Total references split into mitigation, adaptation or mitigation and adaptation per theme 2020. There are a number of areas that clearly speak to mitigation within the adaptation reporting, areas relating to travel and transport as well as recycling or emission reduction illustrate a confusion when reporting on adaptation and a blurring of the boundaries between mitigation and adaptation.[Requires colour].

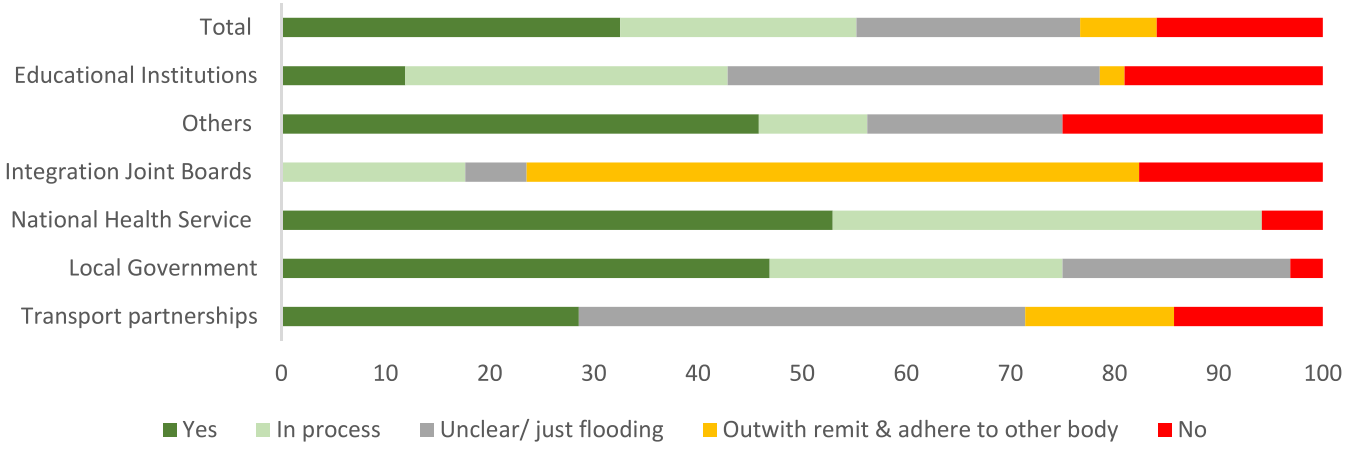

Fig. 4. Responses to Q2 Has the body assessed current and future risks? For reporting year 2020 demonstrates that the majority of local authorities (government) consider themselves to have made considerable progress in risk assessment whilst educational institutes are lagging behind. As a fundamental step in adaptation planning, the implementation of risk assessments provides a good indication of progress towards adaptation [Requires colour].

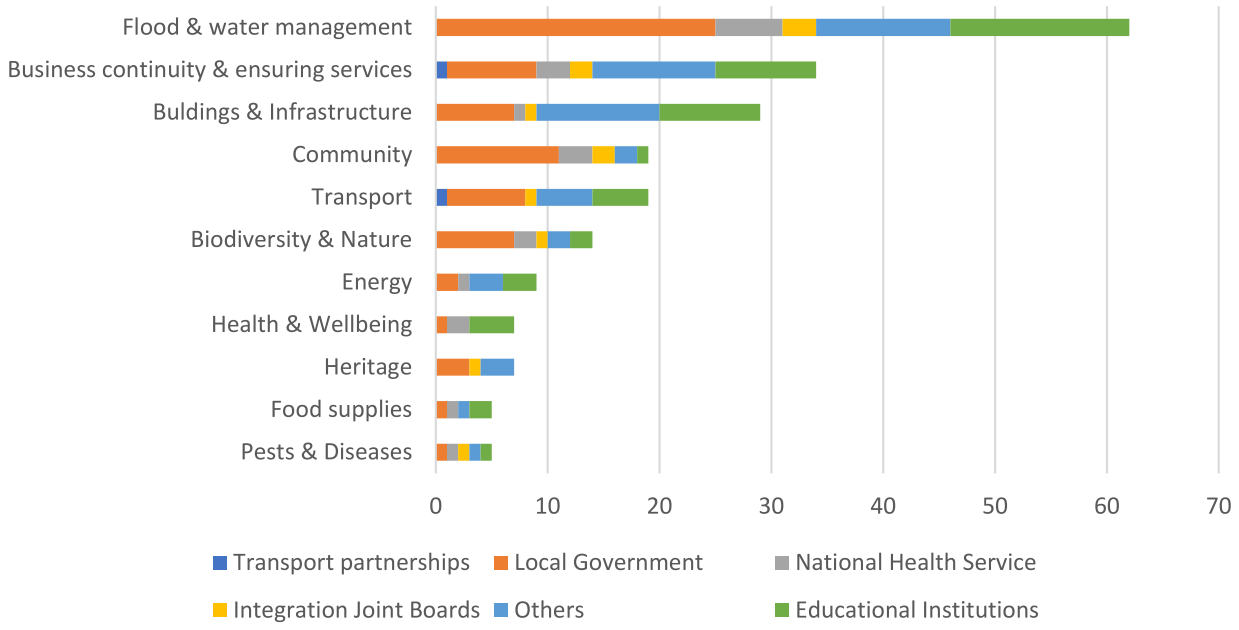

Fig. 5. Themes discussed by bodies in Q2 responses in reporting year 2020 [Requires colour].

conducting unrecognised adaptation actions, "it's the tricky part because people won't see it as adaptation, like in housing for example, they will just see it as energy efficiency"; "all these services are probably doing adaptation…it's just not captured in that way'. Although synergy between mitigation and adaptation is widely accepted as beneficial, evidently this has challenges for reporting on adaptation action as well as the ability to evaluate and monitor progress including any inter-relationships between mitigation and adaptation.

Public sector bodies risk assessment progress

A range of risk assessment approaches and methodologies are currently being used by the public sector in Scotland. Risk assessments can be hazard focused or centred on a particular infrastructure or nature-based asset. With reference to Fig. 4, 33 % of public sector bodies report that they are currently assessing their current and future climate risks based on analysis of the reports. However, interviewees question whether the risk assessments conducted are fit for purpose and if undertaking a risk assessment is leading to the successful implementation of adaptation actions.

Key challenges around risk assessment identified by interviewees relate to knowledge requirements, capacity and implementation. Bodies voiced concerns about the level of knowledge about climate change hazards and potential future risks that is required to conduct a comprehensive climate risk assessment. One specifically noted instances where work on completing a risk assessment has been delayed in order

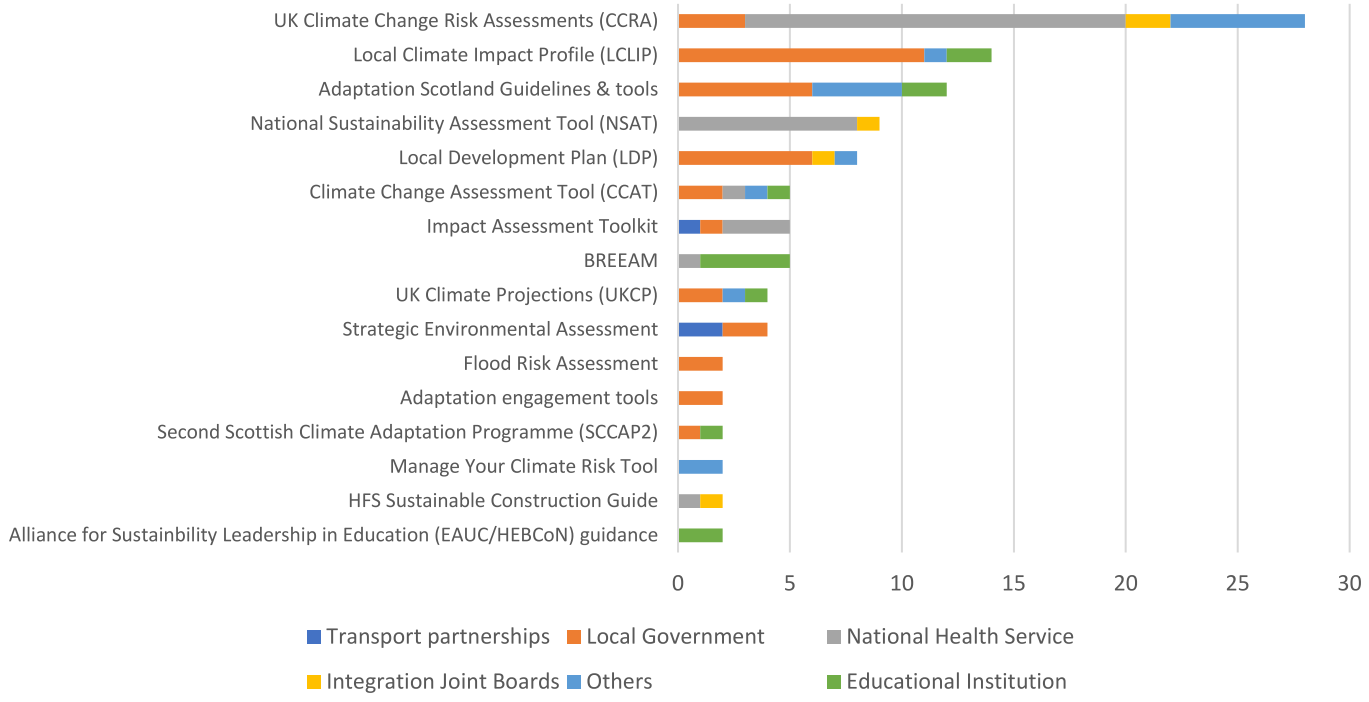

Fig. 6. All tools mentioned by bodies across Q1 and Q2 in reporting year 2020 [Requires colour].

to increase understanding, "we needed to understand climate change before risk assessments took place". Some bodies who had conducted comprehensive risk assessments felt they still lacked preparedness during a hazardous event and therefore questioned uncertainty and difficulties capturing residual risks, stating "I didn't know what I didn't know". Bodies during interviews also cited capacity issues as a barrier to completing a risk assessment with some discussing the idea of working with regional partners to allow for "economies of scale and learning from each other".

In addition, questions arose around the link between completing a risk assessment and implementing adaptation actions. For example, bodies suggested that "often action comes from identification of a physical need on the ground… and not necessarily a risk assessment". For risk assessments that lead to implementation, a focus needs to be given on actions, "it's not just about assessing the risk it's deciding the action from that", "we can't just have a better risk assessment". The chain of challenges from knowledge and capacity to implementation can be summarised by the following, "I think quite often without enough knowledge and understanding it's easy for them [risk assessments] to end up just being paper work exercises without leading to change."

Furthermore, there is a recognition amongst several interviewees that getting from reactive approaches to longer term planning is a critical challenge with one interview stating, "if there's an issue or somethings happened then you would [take] a sort of reactive approach rather than maybe use scenarios", "I think that [risk assessments] are perhaps less developed than you would expect".

Since hazards and adaptation actions are generally reactive, adaptation decision making and planning tends to use past events with little consideration given to potential future events and scenarios, "what you might be doing is investing in something in response to something rather than the likelihood it will happen again", there needs to be "a clear demonstration that something's already happened in that area". This is in part due to public pressure to respond to events and ensure that a similar event that happens in the future does not impact that region as severely as well as the fact that events tend to bring adaptation higher up the agenda. In addition, taking a long-term approach to adaptation requires longer term planning with interviewees citing the challenge of public bodies having year to year budgets and short-term policy influences.

Understanding the potential impacts of extreme weather and hazards is a fundamental aspect of undertaking risk assessments for the creation of adaptation plans. Fig. 5 shows that the theme of flood and water management was referenced most often in responses to Q2. Several bodies reporting on their climate risk assess only part of their risk by focusing only on flooding. Furthermore, 62 % of references made to extreme weather and hazards in Q1 were specifically about flooding. This is perhaps unsurprising given that the annual average rainfall in the period 2010–2019 was 9 % wetter than the 1961–1990 average (UK Climate Risk, 2021).

Tools & frameworks

Information and tools used in adaptation are required to meet two distinct purposes. Firstly, to understand the hazards and potential impacts that may impact the organisation in order to create robust adaptation plans and secondly to get buy-in from senior stakeholders and colleagues who are not convinced that adaptation action is required.

A wide range of tools and frameworks are currently being used by public sector organisations, with a large spread of tools being used by bodies within the same sector, with reference to Fig. 6. Climate change risk assessment reports, conducting local climate impact profiles and guidelines and frameworks from Adaptation Scotland (eg Adaptation Scotland, 2022) are used most commonly across the public sector.

Almost all interviewees stated that poor knowledge of hazards, impacts or adaptation options in general was a key barrier with one interviewee stating that they believe "the challenge is getting that level of expertise and knowledge within an organisation to…drive it [adaptation action] forward." Public sector bodies require local or regional data and analysis tools in order to understand what global warming "actually means regionally", "how it's going to affect our region", and to ascertain if "we [are] positioning ourselves to make sure we're in a good place going forward". Interviewees identified that tools and datasets required must be easy to interpret. This is pertinent due to capacity issues that can make interpreting complex datasets challenging with one interviewee stating that there "probably is a reasonable amount of information to allow you to…undertake an assessment, our issue is that we just haven't had the capacity…to dig into it". With others noting that "pretty complex datasets…need quite a lot of analysis to get what you need out of it". Tools identified as missing relate to accessing and interpreting local data and information so bodies can best understand the potential impacts of hazards in their region or organisation and can communicate this risk to stakeholders.

In the majority of cases, where interviewees mention progress made in conducting risk assessments and implementing adaptation actions this has been down to an individual in the team as opposed to an organisational approach, "if we are advanced, it's in no small part to an individual with a high knowledge level". In another example, an individual within the organisation worked directly with data producers including the UK MET Office in order to "get what we need out of it [the] pretty complex datasets". Interviewees highlighted that guidance could help public sector bodies conduct fit for purpose risk assessments. For example, having "feedback on that [risk assessment and reporting] and being held accountable on that" as well as more of a standardised template for risk assessments. In addition, the idea was put forward that all bodies should be planning for the same level of warming in a consistent approach, "if the Scottish Government agreed on a single plan for it, then we'd be planning for the same thing, probably 3 °C". This reflects the Climate Change Committee's recommendation to adapt to 2 °C while preparing for 4 °C which could be standardised across public sector bodies (Climate Change Committee, 2021a). The need for tighter legislation and "pushing [adaptation] up the agenda" was also discussed.

The second requirement of data and frameworks according to interviewees is to help receive buy-in from senior stakeholders and colleagues who are unconvinced of the need to adapt. The most prominent reasons from this lack of buy-in, as cited by interviewees, include the lack of understanding that extreme events are linked to climate change and the belief that their local area will not be severely impacted by extreme events. Tools around visualisation and storytelling were mentioned here as a way to address the latter. Tools that allow for "conceptualizing…what it will look like when it floods", "not a table, it's not a graph, it's not a map, it's a photograph". Having a "data bank with pictures and stories about climate change affecting certain things in society" was also suggested, "making it real does help". One interviewee summarized this with the following, "But it's getting that story, the simplified story between. This is what's happening. These are the impacts and this is what we have to do. And that sort of simplistic narrative." A number of interviewees stated that they have received push back on adaptation, around the role that climate change has in changing the severity and frequency of extreme events and the level of risk posed by potential future hazards in Scotland. In addition to visualisations and storylines, cost-benefit analysis tools were mentioned for their potential to incentivise adaptation action. The "ability to quantify some sort of value of the risk…the cost associated with not doing that or not responding to that risk", "it's easy to define the cost of building a wall but not necessarily the cost of not building a wall".

Critical analysis and discussion

This research set out to reflect on the progress made by the Scottish public sector in regards to adaptation. Section 3 highlighted some critical areas of concern and challenges for the public sector in progressing

adaptation. In particular, the lack of progress for adaptation compared to mitigation. This section will offer further critical analysis and discussion around the differences and similarities between mitigation and adaptation in terms of: the complexity and drivers associated with progressing adaptation and mitigation actions, the risk and uncertainty involved, collaboration and the number of actions required and measurements and targets associated with mitigation compared to adaptation.

Whilst it is evident that mitigation and adaptation are intrinsically linked, by reducing greenhouse gas emissions there will be less need for adaptation action in the very long run, yet adaptation and mitigation tend to be separated in policy, practice and in research applications (Sharifi, 2021; Sharifi, 2020). This is partly due to the apparent inherent differences between them. The majority of studies present the differences between mitigation and adaptation at the global scale and not at the level of local implementation (Klein et al., 2005; Klein et al., 2007; Sharifi, 2020).

Complexity and drivers

Adaptation is understood to be more complex than mitigation within the Scottish public sector. This complexity relates to understanding the link between climate change and increased occurrences of hazards as well as how to implement adaptation action and how to monitor progress made.

A key challenge facing individuals within the public sector is a lack of buy-in from senior stakeholders and colleagues. While some interviewees felt colleagues took them at their word and implemented adaptation action, in other instances, particularly if the lack of buy-in comes from senior stakeholders, this creates an almost insurmountable barrier for adaptation action. Buy-in from senior stakeholders is critical for climate action, both for mitigation and for adopting adaptation planning (Hoffman and Hoffman, 2007; Kythreotis and Bristow, 2017; Lawrence and Haasnoot, 2017; Rosenzweig et al., 2011). Lack of buy-in was most commonly associated by interviewees due to a lack of awareness and understanding of climate change and how this may impact extreme events in their local area. Lack of awareness is a commonly cited factor leading to lack of climate action both in the mitigation and adaptation space (Rickards et al., 2014b).

Some interviewees mentioned using images in order to tell a local story of adaptation and climate impacts to increase the availability bias of colleagues and senior stakeholders. Visualisations have been shown to help improve likelihood of taking action in some cases, (Chapman et al., 2016; O'Neill and Smith, 2014) particularly if it can raise a visceral concern in audiences, for example, if images show an area they are familiar with being damaged or destroyed by extreme weather events or by sea-level rise. Extreme weather events may also have the potential to induce adaptation-focused policy change (Giordono et al., 2020) and therefore creating a database of hazards in Scotland could help to demonstrate the impacts that adaptation actions could reduce, demonstrating the need for action.

In addition, individuals within public sector bodies have the challenge of simplifying messages to communicate the need for adaptation within their teams as lack of knowledge can be a key disincentive to climate action (Rickards et al., 2014b). Therefore, there is a requirement for upskilling across organisations including at the senior management level to understand the need for adaptation. A potential solution could be training to increase awareness of adaptation in the public sector, for example, by ensuring adaptation is present in carbon literacy training. Raised awareness of climate change through for example carbon literacy training could increase staff engagement (Khatibi et al., 2021; Büchs et al., 2021). This could make more of the organisation aware of what adaptation actions they are currently taking and what adaptation actions are required, helping to move from an individualist to an organisational approach.

Where individuals do make progress on adaptation, in many instances the individual does not remain within the organisation and therefore any advancements made on the adaptation agenda stalls leading to capacity issues. Therefore, increasing adaptation literacy at an organisational level across the public sector is a vital tool (Johnston, 2020; Rickards et al., 2014a). Recruiting skilled adaptation professionals could also reinvigorate teams within the public sector, particularly in circumstances when senior stakeholders' disciplinary backgrounds or perspectives, such as a bias towards short-term gains, could be limiting buy-in to adaptation action taking (Rickards et al., 2014b).

In terms of drivers, interviewees mention that external drivers for mitigation are stronger than those for adaptation in terms of deliverables and funding. The Scottish Government could push adaptation up the agenda an external pressure that could lead to greater buy-in particularly from senior stakeholders in the public sector (Rickards et al., 2014b). Legislation is felt to be required in order to make significant progress in adaptation planning and implementation by increasing awareness.

Risk and uncertainty

Individuals within the public sector require knowledge, data and tools to complete fit for purpose risk assessments and adaptation plans. While capacity is cited as a key barrier in regard to this, the fact that datasets and knowledge relating to climate impacts and risk is "complex" is a key, addressable concern. The level of risk and uncertainty involved in decision making is a key difference between mitigation and adaptation. This is in relation (Sharifi, 2020) to uncertainty involving hazards and climate impacts and how they may change in the future in relation to emission pathways and socio-economic behaviours. Ways of making decisions under uncertainty is vital to make progress in adaptation. Stirling et al (2010) suggest that a plurality of approaches is required for decision making under uncertainty, while a discussion and comparison of the methods is outwith the scope of this research, it is helpful to understand what quadrant of the uncertainty matrix different approaches being suggested by the public sector fall within with reference to Fig. 7. Currently, risk assessments and cost-benefit analysis as well as expert consensus are being discussed or completed most prominently in the Scottish public sector. These approaches fall under the quadrant (see Fig. 7) that assumes that knowledge about possibilities

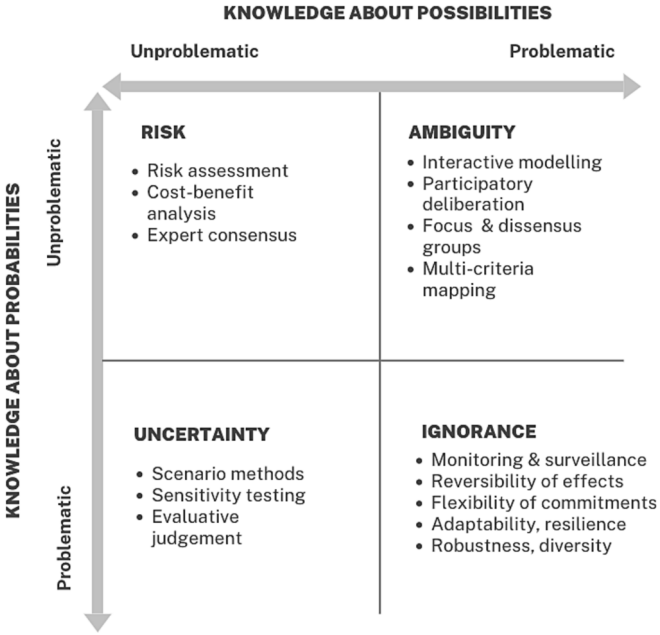

Fig. 7. Uncertainty Matrix adapted from Stirling et al (2010).

and probabilities are "unproblematic". Political pressures do tend to mean that focus is given to this quadrant due to, for example, lack of funding and time pressures (Wassénius and Crona, 2022).This suggests that a wider range of approaches must be brought into decision making around adaptation in the public sector in order to prepare for an unknown future where knowledge about possibilities and probabilities are problematic (see Fig. 7). Several interviewees mentioned the need for scenario methods and narrative building, participatory deliberation with local groups as well as "resilience", moving from the top left to the bottom right quadrant. While the concept of resilience is wider than dealing with uncertainty, it is considered a way of tackling uncertainty when the past is not a reliable indicator of the future (Wassénius and Crona, 2022). Since many traditional risk assessment frameworks were developed for less complex situations than is the case for today's world (the top left of the quadrant) it is important that approaches to risk are adapted and adjusted in order to take into account higher levels of uncertainty and make use of interdisciplinary, quantitative and qualitative approaches.

Wassenius and Crona (2022) suggest ways in which risk assessments can be adjusted in order to be usable under complexity. For example, risk assessments should aim to deal with connection between risks including across disciplines. An interdisciplinary approach to risk therefore appears to be critical. This requires an understanding of low-likelihood, high-impact events not only the most probable events. This could take the form of storylines, "physically self-consisted unfolding of past events or of plausible future events" to assess and communicate scientific evidence in decision-relevant terms. These regional climate scenarios, that interviewees have expressed a requirement for, would need to include high-impact scenarios with quantified conditional impacts and risks including multihazard and correlated risks (de Bruijn et al., 2016; Shepherd et al., 2018; Sutton, 2019). By exploring differing storylines or narratives or through serious games where decisions are made under uncertainty, organisations can experience decision making for an unknown future, under different conditions from the past while gaining experience of making legitimate decisions under high uncertainty levels(Lawrence and Haasnoot, 2017; Rumore et al., 2016; Wu and Lee, 2015). This form of risk management, through scenarios, or climate narratives, ensures that risk assessments do not rely on occurrences of events or on the likelihoods of past events alone (Wassénius and Crona, 2022) as is currently the process in the Scottish public sector for a number of bodies based on interviews and report analysis.

A suggested way forward is to adopt an adaptive process to continuously re-assess risk. This links to the idea of flexibility of commitments and reversibility of effects in the bottom right quadrant of Fig. 7. Adaptation pathways could be a method used to deal with uncertainty and complexity by offering planning approaches that are able to deal with changing conditions over time. They are considered as sequences of actions that can be implemented through time depending on future conditions (Denton et al., 2014; Haasnoot et al., 2013, 2011; Werners et al., 2021). Adaptation pathways can be one of or a combination of "performance-threshold oriented pathways", "multi-stakeholder-oriented pathways" or "transformation-oriented pathways". These key forms of adaptation pathways may be useful to different public sector bodies (Kingsborough et al., 2017; Werners et al., 2021). The performance-threshold-oriented pathway tends to be used when adaptation goals can be quantified and there is a clear, non-contested mandate. For example, an adaptation pathway has been used in relation to the Thames barrier in London where potential future measures are put into place depending on different climate scenarios (Coaffee, 2019). Multi-stakeholder-oriented pathways highlight the multi-stakeholder setting of adaptation planning and implementation. Different stakeholders define and identify thresholds important for local communities as opposed to setting thresholds based on hazard or environmental conditions. The aim is to create pathways that include different forms of knowledge while promoting collaboration. Lastly, transformation-oriented pathways aim to focus on the root causes of vulnerability and recognize a need for changes to values and governance arrangements while also following a participatory and collaborative approach. Werner (2021) highlights key outcomes of adaptation pathways, relevant to the aims of the public sector, namely, meeting short and long-term adaptation needs, promoting collaborative learning, adaptive planning and adaptive capacity and accounting for complexity and long-term change, including a potential need for transformation. Adaptation pathways offer a way to engage a range of stakeholders and collaborate while also monitoring and evaluating to learn from experiences whilst also addressing root causes of vulnerability to climate change (Malloy and Ashcraft, 2020).

While there are methods of dealing with risk and uncertainty involved in adaptation-related risk assessment and management, capacity issues and lack of training mean that building the knowledge and skills required internally is challenging for the public sector. Where bodies have made progress on risk assessment, partnerships have been made with researchers or organisations who are able to "translate" or interpret regional scenarios for decision making purposes. Having embedded researchers within the public sector who could take the role of creating or interpreting local regional scenarios by way of co-production could be a solution here (Webb et al., 2019). Public sector bodies require information and tools that allow an understanding of how climate change is going to affect their region on a local level. This is not a new request, however regional scenarios and case studies are still lacking, hindering local decision making. The role of embedded researchers or "climate translators" has been mentioned in other regions (Hill and Martinez-Diaz, 2020) as a way to develop the skills and knowledge required to understand potential regional impacts and to create regional scenarios or storylines. Another method for developing the skills required for adaptation scenario planning could be the creation of a "boundary organisation"(Kirchhoff et al., 2013). There are several organisations in Scotland that provide information, tools and knowledge to the public sector including ClimateXChange and Adaptation Scotland (Adaptation Scotland, 2022; Wreford et al., 2019) that could fill this role for the public sector. While bodies are receiving guidance on adaptation, the requirements for adaptation (including what scenarios bodies are required to use) remains unclear. The role of a boundary organisation for the public sector would be to co-produce scenarios and storylines for regions in the public sector while allowing for collaboration between regions and bodies. This organisation could also facilitate the creation of adaptation pathways bringing together public sector bodies and communities where collaboration is paramount and help to fill the current skills gap and capacity challenges.

Collaboration and the number of actors

Collaboration was a key theme discussed in the adaptation section of reports and had the third highest number of references made to it in question 1. In addition, all interviewees mentioned either the partnerships or collaborations they have built and how further collaboration may help progress adaptation actions. Collaboration is also a commonly cited difference between adaptation and mitigation as well as the number of actors involved as mitigation is often considered to consist of a few key actors (Klein et al., 2005) mainly the energy and transport sector, while adaptation represents a larger number of actors and sectors including urban planning, nature conservation, coastal management and tourism. Public sector bodies in Scotland are responsible for or play a part across multiple sectors required for adaptation. This makes them a key interface to tackle the challenge of the need of multiple actors (Climate Ready Clyde, 2020; Heidrich et al., 2013).While collaboration and co-production can be challenging (Porter and Dessai, 2017), there is evidence that collaboration is currently happening in the public sector and therefore there is scope to further develop it.

Collaboration is required in the production or co-production of knowledge used to create scenarios or adaptation plans where a range of perspectives and disciplines are required as well as potentially with a

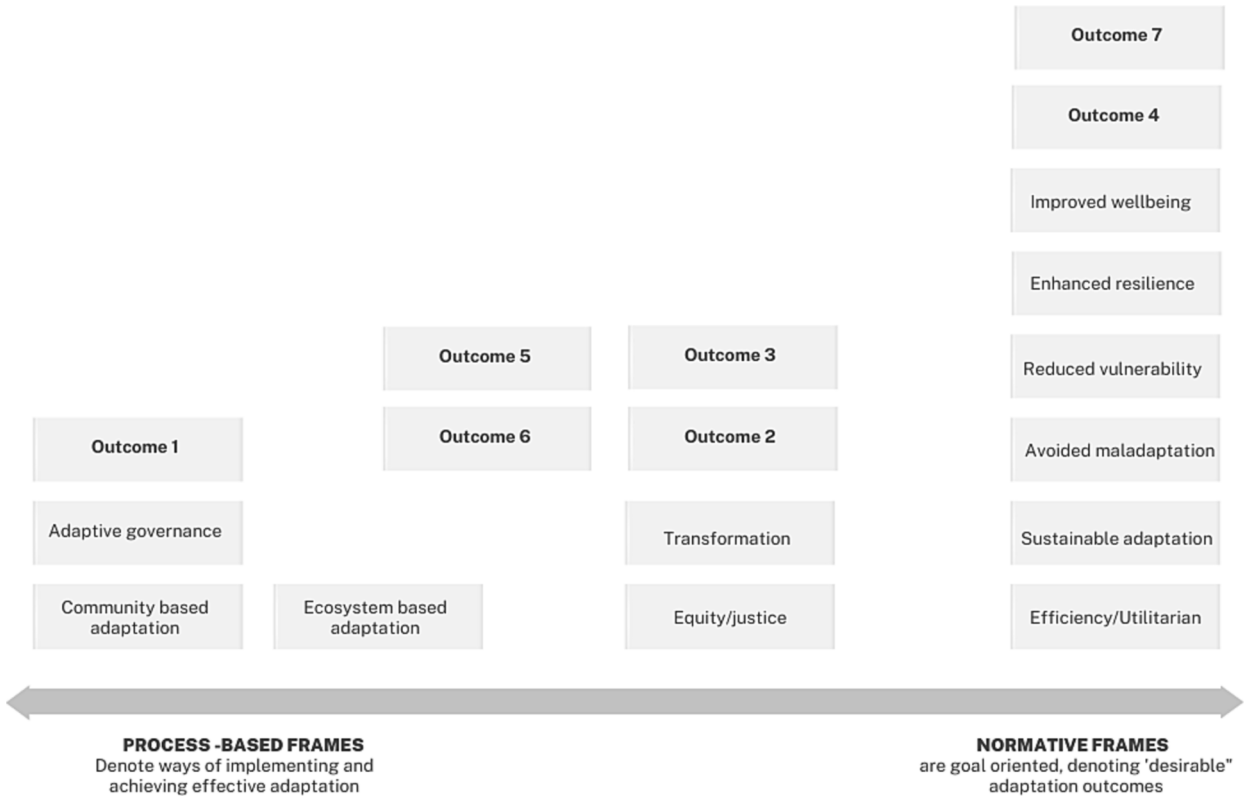

Fig. 8. SCCAP2 outcomes mapped onto measurement frames adapted from Singh et al (2022) (SCCAP2 outcomes are listed in the Appendix).

knowledge broker or boundary organisation (Kirchhoff et al., 2013). Transformative climate science, which refers to science-policy approaches that allow for engagement with various kinds of stakeholders, could play a role here. These approaches tend to focus on interlinkages between different causes of underlying vulnerability to climate change and potential rebound effects (David Tàbara et al., 2019) and focuses on in-context science that is co-produced for the use of society. Collaboration could be increased through co-created adaptation plans for continual shared learning. Coordination of plans could ensure that they are aligned with the national climate framework as well as ensuring that decisions are made with local community groups and stakeholders (Climate Ready Clyde, 2020).

The fact that current siloes, both departmental and sectoral, are acting as a barrier to adaptation was raised by a number of interviewees. This poses challenges for creating an organisational approach to adaptation however also raises an opportunity as the importance of departments of Government being strong and helpful was raised by interviewees. Local authority boundaries lead to a silo effect of funding. An example was given of the need for "collaboration at the landscape scale" when for example a measure in one authority may reduce the impact of a hazard in another authority region for example in the case of a flood. This is also the case for ensuring that maladaptation does not occur.

A key similarity between mitigation and adaptation is their relation to power structures. It is crucial to investigate the power relating to risk creation, who creates the risk and who is most impacted by it (Wassénius and Crona, 2022) as well as who is present and has the power over the creation of adaptation pathways and when deciding how to monitor progress. The central role of power has also been cited as a key barrier in the reduction of emissions globally from largely unchallenged forms of power related to the control of institutions and economic and financial structures which aim to build a future very similar to that of today (Stoddard et al., 2021). An examination of power structures and power relations is therefore critical to progress adaptation in Scotland, both from within bodies themselves and also in relation to heightening collaboration between bodies and with local community groups and stakeholders.

Measurements and targets

A reason why mitigation is believed to have progressed more than adaptation in the Scottish public sector is largely attributed to the existence of a mitigation target ie net-zero by 2045. Interviewees mention they have no long-term plan or target for adaptation. However, there is some debate about the effectiveness of long-term emission reduction targets. For net-zero targets to be credible they require milestones and an implementation plan (Rogelj et al., 2021) and the latest UK Climate Change Committee net-zero assessment report states that there is relatively little detail on how, in practice, emissions will be reduced (Climate Change Committee, 2021b).

Mitigation progress and actions can be measured under one metric, CO_2-equivalents, whereas measuring adaptation progress is more complex as benefits can take multiple forms including monetary losses avoided, human lives saved or cultural values loss avoided (Klein et al., 2007). Singh et al (2022) conducted a review of adaptation literature in order to put forward 11 principles for effective adaptation. The idea being that combinations of frames can be used for tracking progress in adaptation with careful consideration given to the strengths and weaknesses of each frame as some frames provide goal oriented and outcome-based perspectives such as minimizing costs or improving wellbeing while other frames are process-based that are around the ways of implementing and achieving effective adaptation such as adaptive governance or community-based adaptation. Other approaches to adaptation such as transformative adaptation and ecosystem-based adaptation sit between the two perspectives. This demonstrates the difficulties of creating metrics in order to measure effective adaptation while also highlighting the potential danger of a sole adaptation metric that is likely to limit the scope of adaptation, potentially leading to

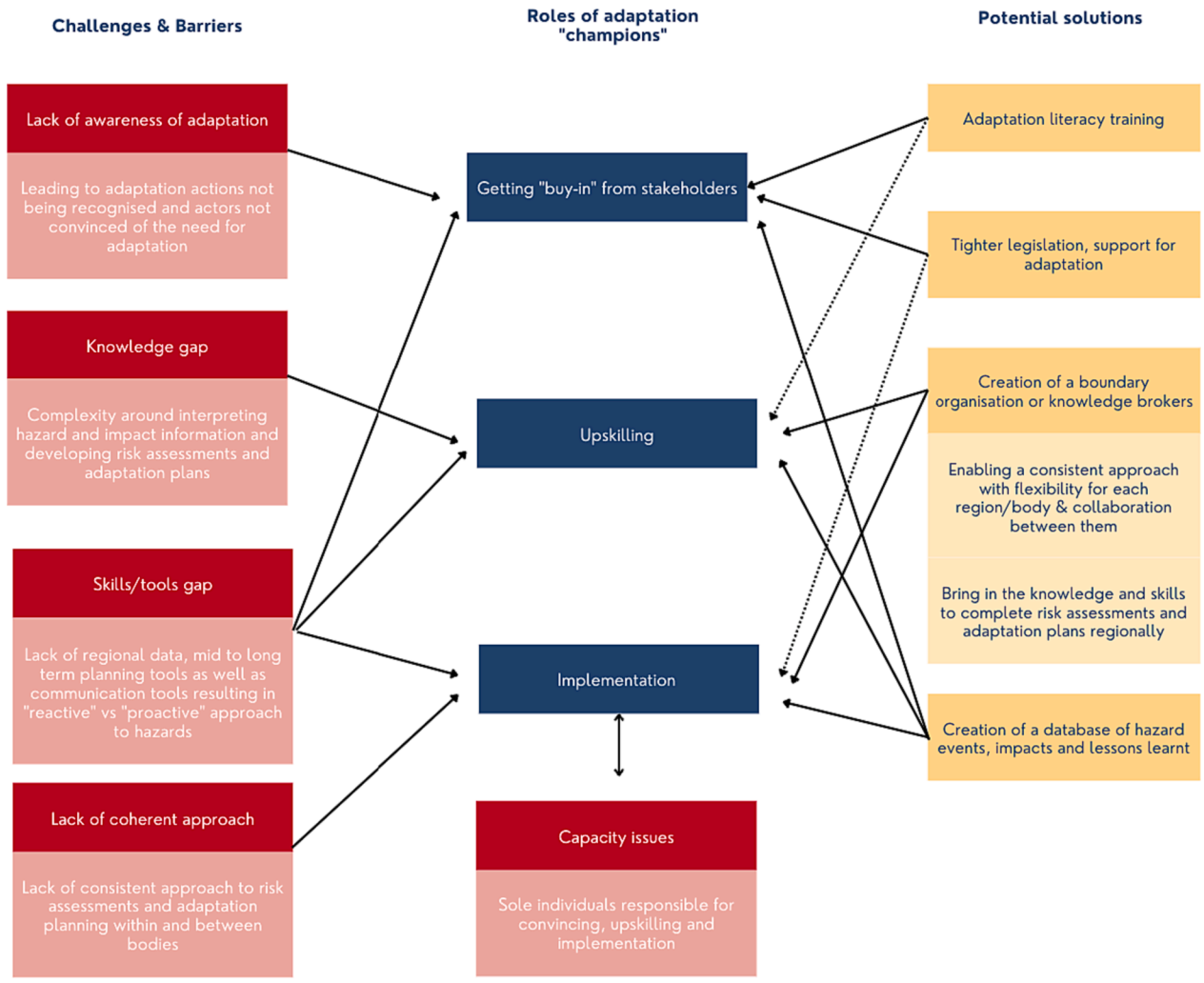

Fig. 9. Links between challenges and potential solutions addressing the role of adaptation "champions" and the lack of organisational approaches to adaptation.

maladaptation or an increase in vulnerability to hazards (Dilling et al., 2019; Schipper, 2022).

Fig. 8 shows where the SCCAP2 outcomes lie relative to process-based and normative-frames. The spread in where these outcomes lie show the difficulty and potential dangers of creating a single metric for adaptation. An alternative approach (Dilling et al., 2019) could be to focus on building long-term adaptive flexibility and capacity. In other words, to focus on the capabilities required to respond to climate change and hazards including, access to healthcare, increased social support and good governance as well as tackling the causes of underlying vulnerability to climate change.

Summary & take-aways

This research reflects on the progress made by public sector bodies in Scotland from risk assessment to implementing adaptation actions. The most commonly referenced theme from the analysis of the adaptation question on priorities for bodies was "Develop Plan" suggesting that the public sector in Scotland is in the planning phase of adaptation. 33 % of public sector bodies are currently reporting on risks based on their response within the public bodies duties reporting however questions have arisen about how fit for purpose these risk assessments are and if undertaking a risk assessment leads to the implementation of adaptation actions.

Our research highlights some key challenges faced by the public sector in Scotland that could be underpinning the lack of progress made in the adaptation space. A key theme that emerged from the analysis of the report and from interviews was the distinction between mitigation and adaptation with numerous interviewees stating that the implementation of adaptation actions is lagging behind mitigation. Our discussion therefore reviewed the key commonly cited differences between adaptation and mitigation at a local level. Differences arise between the two in terms of the complexity associated with each, the risk and level of uncertainty involved, the collaboration and number of actions required and in terms of measurements and targets in the current policy space. A key similarity between mitigation and adaptation however is that there is a current gap between planning and implementation. Therefore, a method to advance adaptation could be connecting to other key policy areas around health and education for example as well as mitigation. Developing an understanding of the synergies between mitigation and adaptation actions in the Scottish public sector is crucial and is a key strategy for accelerating adaptation action in other regions globally (Sharifi, 2021; Sharifi, 2020).

Individuals within public sector bodies currently have the considerable task of trying to gain buy-in fromstakeholders and senior managers while also upskilling in interpreting past data as well as future projections in order to assess climate risk and to create an adaptation plan and implement actions. In summary, key individuals, adaptation "champions" or small teams within public sector bodies are responsible for: gaining buy-in from colleagues, upskilling and implementation. This leads to capacity issues as individuals aim to fill this role both for adaptation and mitigation. These key barriers have been previously

Table A1
Examples of priorities discussed per theme from analysis of Q1.

Theme	Examples
Awareness & Communication	• Raising awareness of climate change impacts in schools and youth groups • Increase awareness of climate change and the need to adapt with key stakeholders and with employees • Raising public awareness of climate change impacts • Raising awareness of flooding and disruption due to weather
Behavioural Change	• Influence behavioural change encouraging staff to become more socially responsible • Behavioural change in relation to transportation • Increase promotion of sustainable behaviours
Buildings & Infrastructure	• Inspecting and maintaining roofs and ensuring they are watertight • Developing smart buildings • Increasing efficiency of buildings • Maintenance of drainage infrastructure Assessing risks of extreme weather on highway infrastructure
Climate Justice	• Understand how climate justice can be incorporated in equality impact assessments • Ensuring just transitions are prioritised in decision making
Community planning partner & Place based adaptation	• Working Community Planning Partnerships • Co-producing adaptation strategies
Demonstrate work & Best practice	• Publicise work and ongoing actions • Organising summits and workshops to demonstrate best practice
Develop Plan	• Developing adaptation plans and strategies • Reviewing plans • Finalising plans
Employee engagement	• Implementing sustainability working groups • Work with staff to create grounds for local wildlife • Updating policies to improve employee involvement
Energy use & Emission reduction	• Energy efficient buildings as part of local housing strategies • Promote/invest in the use of renewable technologies • Local Heat and Energy Efficiency Strategies (LHEES) • Offsetting • Switching to LED lighting
Ensure service to customers	• Updating business continuity plans • Reviewing and updating service plans Including climate change risks on corporate and service risk registers
Extreme weather & hazards	• Local flood management plans Developing/continuing flood protection schemes and studies • Assessing impacts of extreme weather • Reviewing severe weather plans
Finance & Costs	• Economic impact assessments • Securing funding • Costing climate change risks and impacts
Flexible & virtual working	• Working groups created to review opportunities for home working • Investments in digital systems and services • Implementing teleconferencing facilities
Food & Agriculture	• Developing food strategies • Control and prevention of disease in agriculture • Long term water resource and system planning • Reviewing specialist equipment
Human & Public Health	• Promote healthier transport choices • Surveillance of public health trends • Introduce gardens to promote wellbeing
Implement & Deliver Plan	• Delivering a plan or strategy • Continuing or commencing implementation of plan or strategy
Learning & Training	• Training and guidance in impact assessment toolkits • Deliver training to business owners relating to energy efficiency • Undertaking workshops to collect and share information • Developing training for employees
Nature based	• Nature based solutions as drainage solution • Developing a healthy protected and productive environment as adaptation • River restoration projects along with modelling and topographical studies • Identifying habitats and species at greatest risk from climate change • Reviewing tree planting options
Recruitment	• Recruiting a climate change strategy post • Recruiting project management teams for adaptation initiatives
Reduce waste & Recycling	• Increasing recycling rates • Monitoring waste in order to reduce Reduction of plastic onsite • Introducing composting initiatives
Risks & Impacts	• Reporting on climate risks • Assessing climate risk Developing risk registers • Defining climate risks on sites • Identifying ways to manage climate risks • Monitoring climate change risks and impacts
Supply chain & Procurement	• Sharing procurement • Investigating supply chain and procurement processes
Sustainable Development	• Developing a sustainable development strategy • Embedding sustainable development thinking and practices across the organisation • Delivering education for sustainable development
Targets metrics KPIs & Standards	• Introducing adaptation actions, targets and KPIs

(*continued on next page*)

Table A1 (*continued*)

Theme	Examples
	• Meeting targets and objectives to increase efficiency and reduce waste • Developing improvement actions in line with environmental KPIs • Prioritising and progressing environmental targets
Travel & Transport	• Reviewing business travel policies • Increasing car sharing and alternative fuel vehicles • Increasing electric vehicles in fleet • Rolling our electric vehicle charging infrastructure • Encouraging active travel
Use of data, tools, models & frameworks	• Application of Impact Assessment toolkits Use of specific adaptation tools and frameworks • Using sustainability assessment tools • Improve monitoring of data
Work in Partnerships & Collaborations	• Extend joint working with partner organisations • Engage in community resilience networks • Work with colleagues to develop adaptation plans • Working with key stake holders and communities

Table B1
Climate Ready Scotland: Scottish climate change adaptation programme (SCCAP2) outcomes.

Outcome 1	Our communities are inclusive, empowered, resilient and safe in response to the changing climate
Outcome 2	The people in Scotland who are most vulnerable to climate change are able to adapt and climate justice is embedded in climate change adaptation policy
Outcome 3	Our inclusive and sustainable economy is flexible, adaptable and responsive to the changing climate
Outcome 4	Our society's supporting systems are resilient to climate change
Outcome 5	Our natural environment is valued, enjoyed, protected and enhanced and has increased resilience to climate change
Outcome 6	Our coastal and marine environment is valued, enjoyed, protected and enhanced and has increased resilience to climate change
Outcome 7	Our international networks are adaptable to climate change

identified (Adger et al., 2009; Arribas et al., 2022; Kirchhoff et al., 2015; Lee et al., 2022; Milhorance et al., 2022) in other locations and yet, despite being well acknowledged are still posing challenges to adaptation progress.

Therefore, any solutions must work to reduce this burden on key adaptation individuals, "champions", while creating an organisational framework for adaptation and addressing the knowledge and skill gap that currently exists while addressing the key challenges identified including making decisions under uncertainty and working collaboratively with a large number of actors (see Fig. 9).

Further research questions identified from this research include how best to enable collaboration between and within public sector bodies as well as further research on vulnerability to hazards and how to understand and measure local capacity building. A greater understanding of the synergies, co-benefits and trade-offs between mitigation and adaptation actions as well as the links to other policy areas including reducing poverty and healthcare we believe would bolster effective adaptation action. Research is required on different methods of co-producing knowledge which is quantitative, qualitative and transdisciplinary. In other words, in-context science that is useful to society.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A

Tables A1 and B1.

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